LIFE AND CHANCE

BY JOHN BURROUGHS

MANY natural philosophers of our time believe that the appearance of life upon this planet was a fortuitous occurrence—that it was as accidental as the fall of a die, or as the profile of the rocks—entirely the result of the blind hit-and-miss method of Nature as seen in the inorganic world. In the last analysis, according to this view, we are all merely molecular accidents. Let us see in what sense, if any, this may be true. To come at the truth in it we must look upon the fortuitous and the accidental, not as they occur in a world of mechanical movements, but in a world of chemical reactions. The fortuitous among chemical bodies is quite a different thing from the fortuitous among ponderable bodies. We might shake together the parts of a watch for all eternity and not get that adjustment of the wheels and springs that makes a watch. If a thousand of brick are dumped upon the ground, is there any probability that they will take the form of a house? Or if the letters of the alphabet are shaken up together in a bag, is there the slightest chance that they will arrange themselves into words and that the words will arrange themselves into intelligent sentences? In all these things the parts have no attraction for one another, but among chemical compounds, out of which living bodies are built up, there rules the selective force of chemical affinity. The elements select their partners. It is a marriage in which two literally become one. Chemistry is on the road to life; chemical transformations lead up to the transformations we call vital. The physical forces transport and transpose and seek a state of rest; they sort and sift the sands and gravels and clays of the soil, depositing them in a regular series, but they never get beyond the realm of mere chance. The clouds are ever changing, but they never change

into living forms. The waves shift and pile the sands endlessly upon the shore, but the shore is always essentially the same. Gravity is the ruling force. But among chemical bodies a new force appears; chemical affinity is here the determining factor. The law of probability plays a secondary part. Spontaneous combustion, for instance, is a molecular accident only in a limited sense. The antecedent conditions may be in a measure accidental, but the chemical reactions that bring about the rise of temperature to the point of combustion are not accidental; they inhere in the constitution of the elements. Life may be of spontaneous and fortuitous origin in the same sense; not a mere chance happening among unrelated bodies, but the continuation of long-antecedent conditions brought about by that mysterious force we call chemical attraction. This force, as it were, gives the elements eyes, and hands, and feet, and power of choice, and determines the line of their activities. Liquid water, without which life could not exist, was contingent upon the chemical union in fixed properties of the two gases, oxygen and hydrogen; accident may have played a part in the meeting of those two gases, but, once met, under the proper conditions, water was bound to appear. The chemical union of oxygen and silica, which forms so large a part of the earth's surface, was predetermined by the nature of the substances, but the forms of the landscape and the size and the shape of the continents were not in the same sense predetermined. An entirely different disposition of the land surfaces of the globe than the one we behold might have occurred.

Life has its roots in the ground. Everywhere in the inorganic world are movements that foreshadow the organic; inanimate nature is dreaming of the animate. If the worm, as Emerson says, "is striving to be man," the clod is no less striving to be worm. The crystal prepares the way for the cell. The flowing currents of air and water are forerunners of the flowing currents of the living body. Solutions, precipitations, chemical reactions, oxidation, osmotic pressure, assimilation, disassimilation, catalytic power—all antedate and apparently lead up to the movement in matter that we call vital. Life had a large capital to begin on. Its house was well furnished, and its servants awaited its call. It was dowered with the air, the water, the soil, the warmth, the light. The four estates of matter—the solid, the fluid, the gaseous, the ethereal—were its special inheritance. They furnished the conditions. The colloids mothered it, the catalyses fathered it. Electricity, radio-

activity, chemical transformations, are parts of its assets. The forces of life are only the forces of inert matter imbued with a new purpose. In the living body we see the same old chemistry and physics working to higher ends. The chemical transformation of the two substances into a body totally unlike either is a forerunner of the magical changes in the conditions of matter wrought by life. The scientific philosophers find no tendency or activity in living matter that they cannot match in the non-living; hence to them there is no difference between the two that experimental science can grasp. But behold the difference to our consciousness! The difference lies in the purposive activities of one that is absent from the other. There is no purpose in the facets of a crystal in the sense that there is purpose in the forms and structures of living bodies. The hinge of a bivalve has purpose that is determined by the needs of the organism; but what purpose have the lines of cleavage in the rocks, or the contours of the hills, or the courses of the streams? All these things may serve man's purpose, but they are meaningless when regarded in their own light. There is no significance in the whistle of the wind about your house, but a whistle of another kind there in the darkness would startle you. The sounds of inanimate Nature mean nothing, but all sounds that proceed from living, moving things are significant. The rainbow is an optical phenomenon, and, though a beautiful symbol to us mortals, it is not purposive; it plays no part in the physics of the storm. There is no purpose in the glint of the dewdrop nor in the sparkle of the diamond, but there is purpose in the flash of the firefly and in the beam of the glow-worm. The gay plumage of certain birds has a deep significance that does not attach to the brilliant hues of precious stones.

All the movements of Nature may be divided into rational and irrational. The movements of living things are rational; they serve a purpose in meeting the needs of those things; but non-living things have no needs, hence their movements are fortuitous and irrational.

The collisions and disruptions that take place in the vast depths of sidereal space show that chance takes a hand in the game even there, though the universal law of gravitation is not annulled.

Though one has trouble in reconciling the hit-and-miss method of Nature which one sees all about him—her blind, groping, experimental ways—with the obvious purpose and order which one sees in all living bodies, yet the reconciliation some-

how exists. Here life appears and here it goes on amid accidents, delays, waste, failures; at war with itself, at war with the physical forces; rooted in the inorganic, but perpetually crushed and destroyed by it; the long evolutionary process crowned by a man as if he were the end of it all, yet man beset by a thousand enemies, internal and external; his history marked by war, pestilence, famine, suffering, injustice, the monstrous and the abnormal; the methods and aims of intelligence seen everywhere in the organic world, yet intelligence hampered by matter and struggling to be free; chance taking a hand in every game in life, and only life itself seeming superior to the clash of conflicting forces.

We have at once to look upon the organic and inorganic as occupying two different planes. In the world of inert matter one sees only the operation of fixed laws, things cannot be otherwise than as they are; fate rules, the balance of forces is fatefully kept. But when we reach the world of living things all this is changed; the books are never balanced; there is purpose, flexibility, indeterminateness, a shaping of means to an end, an ever-changing fixity, movement which perpetually defeats the tendency in matter to a dead equilibrium. In life matter takes on a new behavior, enters into new combinations, builds up new forms, and in a measure escapes from the law of necessity that rules inanimate bodies.

Life is like those figures which the sculptor sometimes carves when he shows us the form of a youth or a maiden partly freed from the shapeless block of marble—the flowing and delicate lines of life are quickly lost in the ragged and broken lines of the insensate stone. Life is hampered and bound by the fatality of matter in the same way—the organic is still in bonds to the inorganic; it is half one and half the other, and is constantly struggling for mere freedom. This struggle is the drama of evolution, and the drama and tragedy of human history. Its very condition is the union of two opposing elements —fate and freedom wedded in one movement. Life without that which hampers and holds it would not be life; it would have no reality, no expression. The struggle and the antagonism give it body and power. It also opens the door to chance or fortune, as the ancients called it.

The living has to adapt itself to the non-living. The latter is uncompromising; it goes its own way if all life perishes. But life is plastic, inventive, compromising; it takes what it can get; under the pressure of outward conditions it is per-

petually changing; it flows on like a stream, taking the form that external conditions impose upon it, but ever flowing. It would not be life without this inherent movement.

All life asks is opportunity; it takes its chances in the clash of opposing forces; it loses at one point and gains at another; the hazards of time and change modify it, hindering or helping it, but do not extinguish it.

Forms grow old, but the life impulse does not grow old. The animal brain suddenly began to increase in size in Tertiary times. Why? To account for evolution, as I see it, I have to substitute something like the creative impulse of Bergson for the mechanical and fortuitous selection of Darwin. The process of evolution would have stopped, or never have begun, had there not been the inherent tendency of life to struggle up to higher and more complex forms. Mechanical forces seek rest—life forces seek action and change; a static equilibrium is the tendency of the one, a dynamic disequilibrium is the aim of the other. The boy's hoop stands up as long as he keeps it running; it does not have time to fall, gravity is defeated every moment. This is a type of living matter; the life impulse keeps it from stopping and falling down.

It is easy to see that chance, or the law of probability, would have brought the world of dead matter where it is, but the living world presents a different problem. Here we strike the world of organization, parts fitted to parts, and parts subordinated to parts, the many organized into the one. Still there is the same hit-and-miss method of the action and interaction of bodies upon one another, the blind inorganic forces taking a hand in the game of life; the seeds are sown by the chance action of the winds and the floods, the forests are planted and trimmed by chance; the chance actions of squirrels and jays and crows plant the heavy nuts, the grazing cows plant the apple and red-thorn seeds, the fruit-eating birds scatter and drop the many small fruits; there is chance in the planting and trimming and weeding of Nature's garden, and in its locality, but is there chance in the production of her living gardener, in life itself? It is in the reciprocal action of the living and the non-living that life goes on. Chance, inside of mechanical and chemical laws, rules in the one; chance, limited and subordinated to specific ends, rules in the other. Fate and freedom each play a part in life. The plants that spread by runners are free to spread in all directions, but they are fated to run; the vines that climb by tendrils are free to reach

out in all directions, and their tendrils react to whatever they touch, and cling there; the fate of their organization limits them to this mode of getting up in the sun and air. Were there not something fixed and upright, the tendriled vines and plants could not get on in the world. Every tree and every plant has its typical form, but what variations inside that pattern or form! The pines and spruces must throw out their branches in whorls at regular intervals, with one central shoot leading the ranks upward; this is the fixed or stereotyped form, but kill the central shoot, and the tree is free to promote one of the lateral shoots to take the place of the lost leader. The maple-leaves, the oak-leaves, are of fixed patterns, but how hard to find two leaves of the same tree that are exactly alike! The mating of the queen bee and the drones in the air of a summer's day is a chance meeting; the mating of men and women from which marriages result is largely a chance meeting; the fertilization of flowers through the agency of insects is largely a chance occurrence; if the weather is bad for a number of consecutive days, the fertilization does not take place. Chance enters into life in this way. As the inorganic forces are blind and haphazard, and the wind bloweth where it listeth, the success of the organic forces, so far as they draw upon these things, is fortuitous also. Aristotle seems to think that organisms are under the same rule of necessity as prevails in the inorganic world. The rain he says does not fall in order to make the corn grow any more than it falls to spoil the corn when it is threshed out in the field. This is the modern scientific view. The weather system is indifferent to crops; the rain falls by reason of the laws of physics, which always act the same under the same conditions. The rain is not designed for the corn, but the corn avails itself of the rain because it has organic needs. The rain has no needs; inert matter has no needs; it is ruled by necessity, but living things are ruled by a different order of necessity—the necessity arising from their internal spontaneity, of which Aristotle speaks. Aristotle thinks that the teeth and other organs of an animal have a merely accidental relation to its body, and all the parts to which we attribute design; they continue, and are perfected because they are useful. This is natural selection before Darwin. But it is more in agreement with the thought of today to regard all the parts of a living body as the result of an inherent demand of the organism—the "internal spontaneity" which Aristotle had in mind. All parts of living bodies are appropriately

constituted, but the word "appropriate" does not apply in the same sense to winds and clouds.

Contingency attends all forms of life, but determinism rules throughout the realm of insensate matter. The pulp of all fruits is purposeful; it is a wage for any animal that will come and sow this seed, but behold how largely chance enters into this bargain! The heavy nuts have neither hooks nor springs nor wings, but they are toothsome to birds and beasts which supply feet and wings, hence they get scattered. Every part and organ of a living body is purposeful, and not the result of chance as we use the term, but its lot is cast in a world of unorganized material forces, which go their endless rounds from one static condition to another, bound in the iron law of causality.

Nature makes her knives and shears and drills and chisels and augers and hammers a part of a living organism, while with man they are but the mechanical extension of his hand and brain. The parts of a watch are no more purposeful than are the parts of the human body, and are no more the result of a "fortuitous concourse of atoms"; but there is no mystery about a watch; it can all be explained in terms of mechanics plus the mind of man. A living body cannot be so explained; the mystery is in the organizing principle which defies all analysis and all attempts at reproduction. "Natural philosophy," says Professor Soddy, of Glasgow University, "may explain a rainbow, but not a rabbit." We can produce a rainbow at will, but only rabbits can produce rabbits. Yet Professor Soddy seems to think it is not improbable that the time will come when the chemist will be "able to synthesize foodstuffs apart from the life-process." If he means directly from the inorganic elements, I do not see why it would not be as easy to synthesize a rabbit as to synthesize a peach, or a kernel of wheat, or a beefsteak, or an egg, "apart from the life-process."

Fate and freedom play with or against each other in all living things; there is fate in the material conditions of life, and freedom in life itself; their interaction opens the door to chance; freedom of choice in us makes all our mistakes and failures possible. Life is plastic, fluid, a flowing metamorphosis, ever and never the same.

When the wind snatched my hat off my head the other day, and carried it down the street amid a cloud of dust and dry leaves, whisking it across to the other side and between the feet of a colored man bearing a big bundle of excelsior on his shoul-

ders, the hat was completely in the grip of the fateful material forces. But the colored man who seized it and held it was force of another kind. The wind might have carried him away also had it been stronger, but he would at least have struggled and opposed his strength to it. And it is in this that the freedom of life consists: freedom to struggle—to push on, to overcome obstacles, and to turn the inorganic forces against themselves, thus making life strong by the strength of the obstacle it surmounts. We cannot still the wind, but in our sail-boats we can use it.

The extent to which the law of probability rules in the organic world is seen in the fact that the proportion of males to females among all species keeps pretty uniform. In any given city or country there will probably be about the same number of deaths from the various diseases year after year, unless some means of fighting disease are employed. There will be about the same number of weddings and elopements, about the same number of defective persons born, about the same number of persons that reach extreme old age, and of persons above or under the average height. The fluctuations about a common mean in all things will be pretty regular. Indeed, the law of averages plays about as full a part in organic as in inorganic nature. It is probable that just about as many boys will be drowned while skating each winter and while bathing each summer.

In a world of pure mechanics and chemistry all these things would remain about the same, century after century. But the reason and soul of man introduce a new element, and the dice are loaded, at times, at least. Still, the law of probability plays a prominent part in the affairs of men and nations. Over and above our wills and purposes stream the great cosmic currents which we cannot stem, but which, in a measure, we can and do utilize.

Development is what distinguishes the living from the dead. Friction and collision, warmth and moisture, do not develop the pebbles on the beach.

A variation proves advantageous only to something growing, expanding, and seeking advantages and capable of profiting by them. The tendency of the action of outward physical forces upon a body is to produce uniformity, and if living bodies were shaped by these forces alone they would all be alike. If there was not something in every living form that was *sui generis*, they would all be alike.

Professor Soddy says that "inanimate molecules in all their movements obey the law of probability, the law which governs the successive falls of a true die." While this is true in a world of mechanical forces, it certainly is not true in the world of living bodies—here the die is loaded.

The slight variations in the forms of living things are doubtless the result of outward chance occurrences. In passing from the purely mechanical to the vital, we seem to enter a realm where the dice are loaded; chance still plays a part, but a secondary part. The perfect apple on the tree has escaped many mishaps of wind and storm and hostile insect and germ, but it is not a matter of chance that it is an apple, and that it is sweet or sour, red or green, round or flat. That species of apple is always thus with possible modifications. Soil, climate, exposure, culture, all have their influence.

In all marriages and social relations chance plays a part—a chance meeting, an auspicious moment—but sex and the social instinct are not a matter of chance. There is no chance in the workings of the Mendelian law; it is mathematically exact.

If a hybrid which results from the crossing of two varieties that differ from each other only in one specific character, as in color, or tallness, or shortness, be planted, we know that one-fourth of the seeds will take on the character of one grandparent, and one-fourth take on the character of the other, and that the other two-fourths of them will take on the character of the hybrid, and that this order will repeat itself endlessly. Chance takes no part in the result. The dominant characters are constantly separated from each other in the second generation to the extent of one-half, while the other half remains hybrid.

The element of chance enters into all the operations of outward nature. Not a flower blooms, not a fruit forms, not a drop of rain falls, not a child is born, but is more or less contingent upon the changes and fluctuations of the natural currents and forces. But the capacity of matter itself to produce life we cannot think of as accidental; only its development is subject to the law of chance in a world of conflicting forces.

If the seed did not possess an innate tendency to grow and unfold under favoring conditions, the flower, the fruit, could not appear, or the child be born. And if matter did not possess potential life, life could never have appeared in the world.

I conceive that the appearance of life upon this globe was a matter of chance in the same way that fertilization or impregnation in the vegetable and animal world is a matter of chance. There is the possibility of fertilization to start with, and there is the inherent tendency, but unless conditions favor—conditions that are contingent upon many things—it does not take place. In the vegetable world, storms, frosts, rains, floods may prevent fertilization; or the part played by insects may be negatived in some way. In the animal world, external conditions, as well as internal, must also favor, and fortune certainly plays a part in the game. In cold late springs the first birds' nests contain fewer eggs than they do in warm, early seasons. One summer there is an invasion of insect pests—grasshoppers, or tent caterpillars, or forest worms—the chance conditions favored them; the next season the country may be quite free from them, the conditions having been reversed. The slow or the rapid increase of the population of a country is contingent upon many things. Economic conditions play a part, climate plays a part, the geography and the geology play a part. What a part the Gulf Stream has played in the life of the British Islands! What a part a great river, an inland sea, or a much broken coast-line plays in the life of the countries to which these belong! Life is expansive, tends to push out and develop, but it is at the mercy of external conditions. Environment is either a check or a stimulant.

The origin of life, and the many forms it has taken, were probably a matter of chance in the same sense that the origin of springs and streams and the formation of rivers were matters of chance. Given our weather system, and the unequal elevation of land above the sea, and fountains and streams are bound to appear, but they will all be modified and shaped by the chance conditions they encounter. Water will flow, and the tendency of life to push out and on, and organize itself into new forms, is equally inherent. It seems to me we have to take into account this innate expansive or evolutionary force in living matter. To ask whence it comes, how it is related to the matter which it animates, as mankind so long have asked, is at once to get beyond sounding. All forms of life bear the stamp of the environment. Life must adapt itself to its material conditions. And this living adaptation of life to its environment is radically different from a mechanical adjustment. Inanimate bodies adjust themselves, animate bodies adapt themselves. It is this power of adaptation which makes all purely mechanistic

conceptions of life so inadequate. The only machine that can fit itself to the medium in which it moves is the living machine. To inquire into the fitness of the environment is to reverse the problem, and leads to confusion; since the environment is uncompromising, and life must adapt itself to it or cease to be. Man can and does alter his environment to a limited extent, but not so radically as his environment alters him. He cannot change the air he breathes, or the water he drinks, or the nature of the food he eats, nor change his vital relations to the physical world. His mechanical relations, to a certain extent, wait upon his will, but his vital relations are for ever fixed. The place and the hour leave their mark upon everything—more upon the plastic and adaptive forms of life than upon the rigid and immobile forms of death. If you and I had been born in another month, another season, or in another country than we were, can there be any doubt that we should have been quite other than we are? If Carlyle had come and settled here when Emerson invited him, is it not almost certain that his outlook upon life would have been radically changed, and his literary output different? The currents flow; life molds itself to the moments as they fly. The almost infinite diversities of types and characters attest the influence of the chance happenings in the environment. The plains beget one type of life; the mountains, the desert, the sea, the wilderness beget others. The professions and occupations beget their types. The general type of a race long adjusted to its environment—the English, the French, the Arabian, the Mongolian—remains fairly constant, but inside this constancy occur the slight local differences owing to differences in environment. No doubt extraordinary men are in a measure the result of happy accident. There are determining or favoring factors—race, climate, family inheritance, and so on—and there are modifying and fortuitous factors in the daily lives and habits of the parents and in the social conditions. The web of human life is so complex, so many influences and inheritances converge and unite in the genesis of every life, that the elements of chance or fortune inevitably play a part. The malformed, the underwitted, the monstrosities, the still-born, all afford evidence of how the plans of Nature are thwarted or marred by accident. This factor of chance invades even the life of the cells, and occasionally some part is absent or defective.

The forms and distributions of bodies in inorganic nature are not important; any other scheme or rearrangement would do

just as well. The wonderful monumental and architectural rock-forms in the great Southwest are purely a matter of chance—that is, they serve no special purpose, though, given the kind of rock, and the conditions, they are inevitable; they are fated to be thus and not otherwise. But the men and women who make long journeys to view the marvelous spectacle are not in the same way a matter of chance, and their going thither is not a matter of chance; other than physical causes have determined the journey. Their desire to make the journey has its physical basis, but the journey itself was not inevitable like the flow of water down-hill, or like the geometric forms of the rocks themselves. A psychic principle played a part.

Man's freedom is not that of the wind which bloweth where it listeth, but freedom to go against the wind, or to conquer and use the forces that oppose him. There is no movement in inanimate nature that typifies human freedom; only living beings withstand and turn to their own account the forces of dead matter.

Man's work is geometric; he runs to angles and right lines; in other words, to parts and fragments. The circuitous method of Nature—her waste, her delays, her confusion, her endless seeking, her survival of the fittest, her all-around-the-horizon activities—he seeks to avoid, because he is not concerned with the All, but with a part. He aims at victories now and here, and not in the next geologic age. He would eliminate the element of chance. He does not wait for the winds and the floods to sow his seeds or plant his trees, or for the storms to trim and thin his forests; he takes short cuts, he saves time because he has not all time; he selects and abridges and cuts out, and reaches his ends by direct, geometric methods.

The red-thorn in the pasture is constantly cropped back by the cattle; the first shoot is browsed off half its length or more, but the push of life is behind it, and it throws out one or more lateral shoots; the ends of these are nipped, and the shoots that remain again subdivide, thus causing the would-be tree to spread out wider and wider upon the ground. The cropping continues, every new shoot is nipped, and the bush rises slowly as its circle extends farther and farther. Its progress is slow. Every season it goes through the same ordeal; every nip from the cows is met by new subdivisions of the shoots, till the rising bush becomes an impenetrable network of short, thorny branches. The mass is so dense that only the small birds can enter it. I have seen a song-sparrow take

refuge in it when hotly pursued by a hawk. The hawk flies round and round, unable to reach his victim. As inevitably as fate, the mass rises in the form of a cone, pushing its enemy farther and farther away till it is four or five feet high and as many feet broad at the base. Its triumph is now near at hand. Its top reaches a point where the cattle do not easily reach; they neglect the central twig at the apex of the cone; this shoots up, and having the whole push of the extensive root system of the tree behind it, grows rapidly as if in a race for life. I see such a red-thorn daily in my walks. Last year it won with this central shoot; this year it has made rapid progress, and now it has a stalk two feet high which the cattle cannot again crop. They will continue to crop the cone beneath it as long as fresh shoots are put out, but as the life of the tree is more and more drawn off from this mound at the base, and transferred to the rising top, the base soon ceases to grow and slowly dies. So that in a few years more there stands the tree in the shape of an hour-glass, the upper half flourishing, the lower half at a standstill or slowly going back. A few years more and the hour-glass form has faded; only a part of the lower half remains, and so the tree, after a struggle of many years, comes into shape and drops its fruit to the cattle that were so bent on destroying it, and who, by eating this fruit, plant more thorn-trees all over the landscape. Not all species of trees possess this power of struggling successfully against their enemies. The linden, for instance, when cropped by the cattle, resorts to no such tactics as do the apple and red-thorn. In its simplicity it pushes out new shoots each year to be cropped off by the cattle, and it never gets above their reach. The push of life is there, but it is along right lines. There is no manœuvring for advantage, as with the thorn.

The red-thorn in the pasture, struggling to become a tree, is a good type of life. Accident and destiny enter into its problem in due proportion. Accidents are analogous to the grazing cattle, and destiny to the inherent nature of the tree. All life is certainly more or less a struggle against opposing forces, and were it not for the push of life within, living bodies would soon cease to be such; and if the part played by changing fortunes without were greater or less than it is, these bodies might present a far different appearance from that which we now behold.

JOHN BURROUGHS.